

Designing the medieval new town

Wim Boerefijn

Instituut voor Kunstgeschiedenis en Archeologie, Rijks Universiteit Leiden
Doelensteeg 16, postbus 9515, 2300 RA Leiden, The Netherlands
E-mail: wim_boerefijn@hotmail.com

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Abstract. *The hypothesis that complex geometry has been used as the basis for the design of medieval urban layouts is contested. In particular, the case of the bastide of Grenade-sur-Garonne in south-west France is analysed, comparing the geometrical hypotheses with measurements on the twentieth-century cadastral plan. In this case, it appears far more likely that the plan was designed by using a much simpler metrology. Further, it is suggested that the fields north and south of Grenade were probably originally laid out as house lots.*

Key Words: medieval, town planning, geometry, Grenade-sur-Garonne, bastides

There has recently been a discussion in this journal on the nature and meaning of geometry in medieval town planning. In the town of Grenade-sur-Garonne in south-west France is mentioned several times as an example of complicated geometrical design. This hypothesis was first proposed by François Bucher (1972). In this paper I propose to set it in the wider context of medieval town planning and architectural design, and demonstrate that, in the case of Grenade at least, it is unfounded.

Design geometry

It is generally accepted that, in medieval times, much as in ancient and modern times, geometry was one of the basic instruments in architectural design. The idea that regular geometrical figures or geometrical adaptations were used as a method of determining fixed position or proportion in designing plans and elevations in medieval architecture has been

recognized by architectural historians since the nineteenth century. There are contemporary sources supporting these ideas,¹ but there is still no consensus about how, to what extent, and, more importantly for the general history of culture, for what reason, geometry ruled design.² The reconstruction of the geometrical design systems of the major architectural monuments of the Middle Ages has, since the nineteenth century, become a special branch within the discipline of architectural history. It is, however, obvious that many of the hundreds of design methods that have been hypothesized, starting with Cesariano's reconstruction of the design of Milan cathedral from 1521, can be discarded, since they often do not fit the actual dimensions, are anachronistically complicated or against the logic of design. This is clearly shown by Konrad Hecht, who, as a case study, has compared fourteen different hypothesized design systems of the Münster tower in Freiburg-im-Breisgau.³ From Hecht's research it is clear that the

large majority of these reconstructions are very inaccurate and do not fit the real proportions.⁴ Much nonsense regarding medieval design geometry also comes from the romantic notions that this geometry was secret, sacred, or riddled with pagan symbolism which druids passed on to freemasons.⁵

Research on architectural design-geometry has relatively seldom been applied to the field of medieval urban planning. The general idea people have about medieval town-building is that it was ruled by the principle of 'spontaneous' or 'natural' growth.⁶ Despite an increasing interest in medieval urban history among historians from different sub-disciplines, and a growing stream of publications on this subject, surprisingly few people know that, in the high and late Middle Ages, an enormous number of towns were newly founded. Hundreds of towns, and even more villages, were built from the ground up, on locations where no settlement, or only modest habitation, had been beforehand.

These new towns were founded all through the Middle Ages, but the highest numbers were created between the twelfth and the fourteenth centuries, with a peak period at the end of the thirteenth century. All kinds of feudal landlords, from the highest to the lowest rank, be it lay or ecclesiastical, tried to found new towns on their estates, in order to gain economic, political or military power. The settlers of the new towns were attracted by fiscal, economic and juridical advantages granted by the founding lord. In spite of these advantages, many of these newly-founded towns did not prove very successful: indeed a substantial number of them failed.⁷

Nonetheless, the number of more or less successful newly-founded towns in Europe was so large – certainly more than a thousand in the twelfth to fourteenth centuries – that the total number of towns in that continent was more than doubled. Medieval new towns were very often built according to a pre-conceived, well-ordered ground plan, which means that they do not have the narrow and twisting streets and the irregular

labyrinthine ground plan that are so often thought of as typical for the image of the medieval town. These new towns were often laid out in the form of a grid pattern with sets of parallel streets that cross at right angles, although within this basic pattern one can often observe irregularities caused by different kinds of circumstances, such as the form of the pre-existing landscape, mixed land-ownership and technical faults at the time of the layout, or processes of change in later periods. The idea of medieval urbanism as generally characterized by the process of 'spontaneous organic' growth can be discounted.⁸

Unfortunately, we do not know much about the way in which medieval urban projects were designed. We know a little about their organization and execution, but almost nothing about the design stage: how and why specific motives in the spatial layout were chosen, whether specific examples were followed, and to what extent planners relied on previous experiences. In rare cases we know a little, in others we can argue from logic or analogy, but often we are left without clues.

Nevertheless, a number of theories have been put forward, proposing complex geometrical figures underlying the designs of medieval new towns.⁹ Some of these hardly need to be considered, because of their implausibility. It is, however, obvious that geometry, however basic, was important in the planning and execution of the design of regular town plans. After all, a regular grid cannot be laid out without the use of geometry. Nonetheless one has to ask whether there really was a 'hidden' geometry for determining dimensions, because these dimensions can also be determined arithmetically, as round numbers of the unit of measurement, or as arithmetical relationships, as for instance the musical harmonies 1:2, 2:3 etc.¹⁰

Grenade-sur-Garonne

The charmingly quiet town of Grenade-sur-Garonne, which lies 20km north-west of

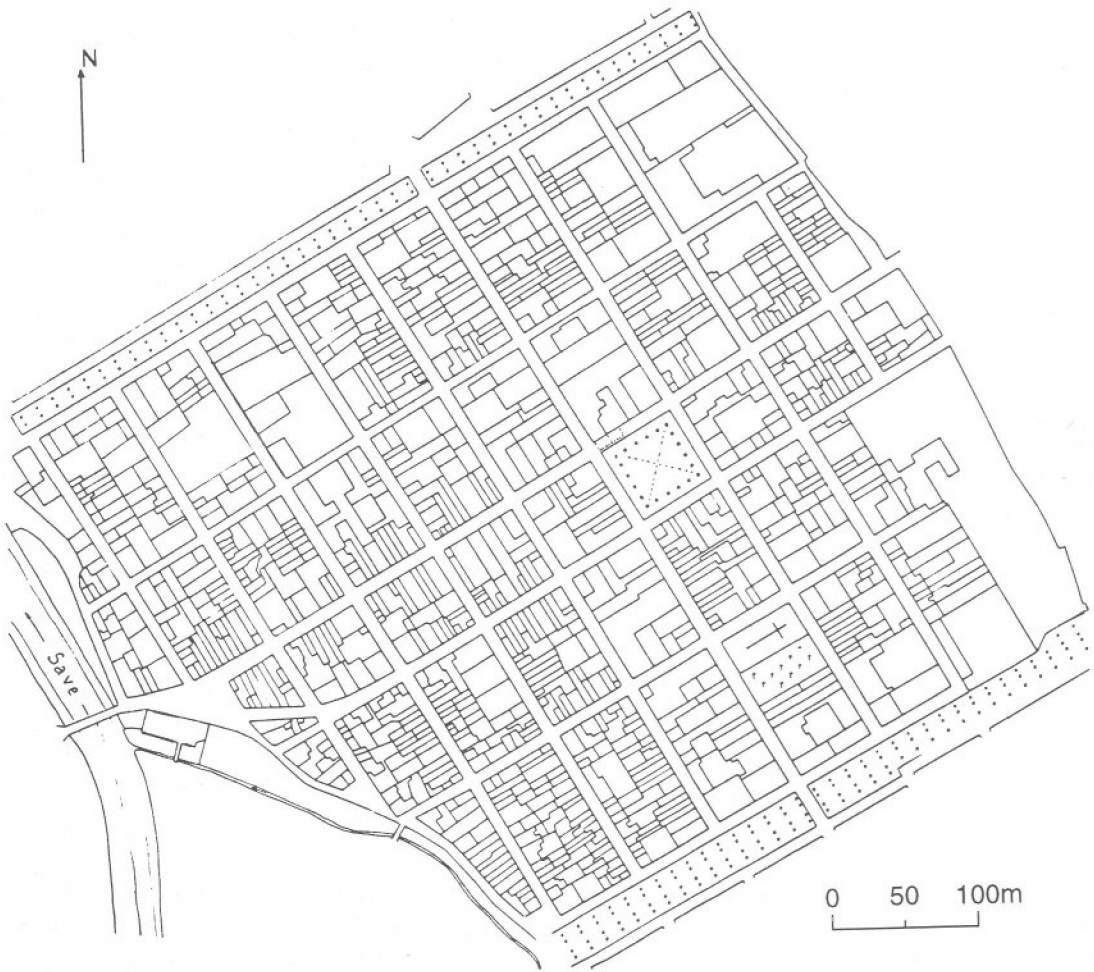


Figure 1. Grenade-sur-Garonne, modern plan of the old town centre.

Toulouse on the bank of the Garonne, clearly shows by the regularity of its ground plan that it was once deliberately planned (Figure 1). The town was founded in 1290 by the royal officer, Eustache de Beaumarchais, in co-operation with the abbey of Grand-selve, which held the land on which the town was built. We know this from a document which laid down the conditions under which the officials of both parties agreed to found this town in co-operation, the so-called *acte du paréage*.¹¹ In the second half of the thirteenth century and the first half of the fourteenth century hundreds of new towns were founded in south-western France by all kinds of landlords, often working together in *paréage*. These new towns are generally

known as *bastides*.¹² Amongst these, Grenade is a rather special case, since it was planned to be considerably larger than almost all other *bastides*, with an initial provision for 3000 house lots.¹³ This anticipated number of settlers was, however, never attained.

Bucher proposed a hypothetical geometrical method of design for the plan of the new town of Grenade in an article about medieval architectural design methods (Figure 2).¹⁴ The plan of the town, which is laid out on a regular grid with geometrical accuracy, has in its historical core three different lengths of street blocks. While in one direction the streets are laid out at equal distances, in the other direction they are not equally spaced. According to Bucher, the

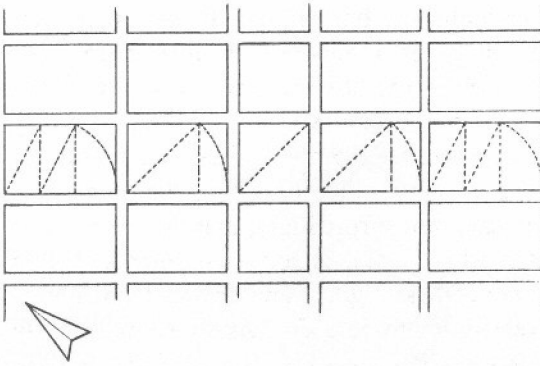


Figure 2. The method of determining the proportions of the chequers in the design of Grenade's town plan, according to Bucher. The central block is square, the larger ones, next to it, are proportioned by the 'diagon' ($1:\sqrt{2}$), and the largest blocks by the 'auron' ($2:1+\sqrt{5}$).

spacing of these latter streets was fixed by geometrically determined distances. Starting with the central row of square blocks, interrupted by the market square, the length of the 'larger blocks', lying in the rows north-west and south-east of it, would be given by the length of the diagonal of the square. The length of the 'largest blocks' (again in rows lying north-west and south-east of the 'larger blocks') would then be generated by the *auron*. The *auron*, or golden-section rectangle, is dimensioned by rotating the diagonal of the half-square (Figure 2).¹⁵ According to Bucher, this is very simple and clear, and would be analogous to the geometrical techniques which were often used in medieval architectural planning (especially for churches). However, although Bucher points to the Grenade plan as an example of this design method, he does not explain it exactly, or prove the thesis by giving actual measurements. He comments that the same principle can be found in the plans of Sainte-Foy-la-Grande (another *bastide*, of 1255) and the new towns founded by the Zähringer dynasty in the north-west of Switzerland and the south-west of Germany.¹⁶ However, the question of whether this hypothesis actually corresponds with the evidence of the town plan of Grenade is not addressed. Furthermore, it is doubtful whether these geometrical

techniques were used as often as Bucher and others suggest. As with many theories in which similar ideas have been proposed, I would suggest that the data are not very reliable: actual dimensions are twisted in order to make buildings and urban structures conform to hypotheses.¹⁷

David Friedman has tried to check whether Bucher's theory actually fits Grenade's town plan. After taking measurements he found that it did not do so completely; but part of Bucher's theory is substantiated by Friedman. He found that the first part of Bucher's theory is correct when measurements are taken from the centre line of the streets: the square blocks then have sides of 64m and diagonals of 90.5m, and this comes very close to the long side of the 'larger blocks', which is 90.4m according to Friedman. Although Friedman seems to have misunderstood Bucher's idea, he is right in finding that the length of the 'largest blocks' does not correspond with Bucher's theory.¹⁸ So, Friedman concluded, Bucher's theory is substantiated as far as the relation of the square blocks to the 'larger blocks' is concerned.

It seems that Kostof has, in his turn, misunderstood Friedman. He depicts the geometrical scheme as if five different sizes of blocks in Grenade were all related as follows: the diagonal of the square block is equal to the long side of the larger block, whose diagonal, in its turn, is equal to the long side of the next larger block, and so on for two more stages.¹⁹ Kostof's illustration of this system is very schematic (Figure 3) and has not much to do with the actual plan of Grenade, where there are not five regular rows of blocks of progressively greater length, but just three.

Randolph understood Bucher in still another way, when he wrote that the blocks east and west of the square have long sides which equal the diagonal of the square. This accords with Friedman's finding and probably is what Bucher intended. However, Randolph considered the blocks north and south of the square to be *aurons*. Here he seems to have been referring to the square

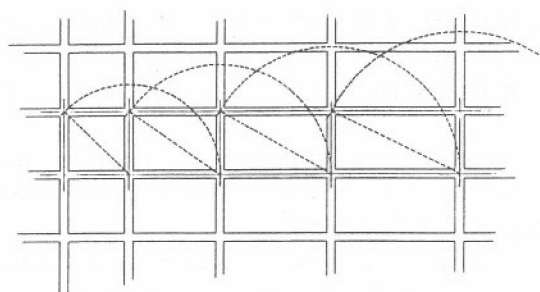


Figure 3. The method of determining the proportions of the chequers in the design of Grenade's town plan, according to Kostof. Starting from the square block, the long side of the larger block is given by the diagonal of the square; the long side of the next larger block again by the diagonal of the preceding block; and so on.

blocks in the central NE-SW row, not the 'largest' blocks to which Bucher was referring.²⁰ It is obvious, however, that these blocks are not *aurons*: they are squares. Further, Randolph accepts Bucher's statement that this geometrical harmony was taken from the plan of Sainte-Foy-la-Grande, not bothering to check whether this is actually so.²¹ All in all, this is a curious case of uncritical acceptance, Friedman excepted, and misunderstandings piled one on top of the other, based on an unsubstantiated, almost casual, remark by Bucher.

Recently, in this journal, Lilley, Slater and Scrase contributed to a discussion over the use and function of geometry in medieval town-plan design.²² Although they had conflicting standpoints on several aspects, they all agreed that Grenade was designed by use of complex geometry in the way that Bucher suggested. Therefore, it would be appropriate to examine the plan of Grenade, in order to check whether, or to what extent, Bucher's theory really fits with the actual dimensions in Grenade's plan.

Plan analysis of the bastide of Grenade-sur-Garonne

I should like to propose a different genesis of the design of Grenade's plan. In my opinion, the design is not based on geometrical

manipulation, but on simply taking regular multiples of a standard lot size to arrive at the size of the blocks. My analysis is based on the 1:1250 cadastral plan.²³ Taking many measurements from the plan, I first tried to find the actual dimensions of the blocks. It appears, not surprisingly, that the plan, when studied in detail, is not as regular as might seem at first sight. The streets from north-west to south-east, for instance, are slightly curved, their extremes lying about 1-1.7m farther westward from a straight tangent line along their centre. This can also be observed easily in reality. The streets in the other direction (SW-NE) converge slightly towards the south-west (on that side of the town the two streets that separate 'larger' from 'largest blocks' are about 5.2m closer to each other than on the north-east side), the north-western boundary street being the only exception to this. Hence, the blocks on the north-eastern side of town are longer than the ones on the south-western side.

Consequently, the dimensions of the street blocks show a considerable variety, of which I have calculated the averages. Thus, the lengths of the three types of blocks proved to be 55.05m, 82.44m, and 110.11m.²⁴ From these dimensions it is almost disappointingly clear that the 'larger blocks' are one and a half times as long as the square blocks, and that the 'largest blocks' are twice as long.²⁵

In the *charte de paréage* it is stated that the bastide's foundation provided for 3000 households, which required 3000 house lots, 3000 garden plots and 2000 fields of arable. The house lot was to measure 5 x 15 *brasses*,²⁶ costing 5 *denier* rent a year. According to Lavigne, this would be about 8m x 24m.²⁷ However, given the calculated sizes of the chequers in the cadastral plan, it would seem more likely that they measured about 9.175m x 27.525m, so that the different types of blocks would have contained 12, 18 and 24 lots, lying back to back. The *brasse* would measure 1.835m in that case. When we try to verify this from the actual lots in the plan, we are first confronted with the fact that it does not immediately suggest an initial division into

house lots of equal size. But we have to remember that 700 years have passed, and while the boundaries between public and private space seem to have been stable, the ownership of private land and private buildings can change, and apparently has changed, considerably over this long period. However, there are many lots of approximately these dimensions. In length they extend up to half the width of the blocks, and in breadth they are one-sixth of the side of the square blocks, one-ninth of the length of the 'larger blocks' and one-twelfth of the 'largest' ones. Most present-day lots, though, are smaller, most probably owing to subdivision, while there are also some larger ones, which must have been amalgamated.

One must, however, always be careful not automatically to suppose that the intended lots, as described in the foundation document, were indeed laid out and distributed correspondingly. Research elsewhere in Europe has shown the probability of those standard lots being also issued in halves, one and a halves, or multiples.²⁸ So, eventually, it may be that the many lots in Grenade with about half, one and a half and double the width of the standard lot were originally created thus. The church with its grounds occupies the space of twelve standard lots of one of the 'largest blocks', taking up a square plot which is half of the block.

The streets of Grenade's town centre, measured from the cadastral plan, are for the most part about 8.55m wide. The only regular exception to this width are the two streets which separate the 'larger blocks' from the 'largest' ones. These streets are only *c.* 7.02m wide.²⁹ The streets were possibly originally intended to be five and four *brasses* wide. Calculating from the *brasse* length just described, this would have resulted in widths of 9.175m (the same as the house lot) and 7.34m. The differences between these figures and the averages derived from the plan may partly reflect inaccuracies in the plan or in my measurements. But it is also possible that the differences are partly caused by the rebuilding of the houses, over and over again

during seven centuries: over such a period there would be a tendency for public space to be encroached upon.³⁰

In conclusion, the evidence seems to contradict Bucher's theory of complicated geometrical design. Instead, the dimensions in the present-day plan show simple arithmetic proportions, which were most probably generated by the choice for particular numbers of theoretically identical lots within the different blocks. Or, possibly, it was not the choice for particular numbers of lots, but rather the choice for particular proportions that determined the dimensions of the blocks. There must be some significance in the fact that the standard house lot was proportioned 1:3, and the blocks 1:1, 2:3 and 1:2. It is clear that simple arithmetical harmonies, corresponding to musical harmonies, were favoured, and it is obvious that these proportions answered to a sense of order. It is possible to connect these proportions to all sorts of specific symbolic meanings, as students of medieval art and architecture have often done, their efforts motivated by an interest in medieval symbolism and numerology. But, to me, it seems more sensible to see the arithmetic proportions and the geometry of the orthogonal grid as a deliberate effort to achieve order. This order is, of course, to be understood in several different spheres: spatially, socially, administratively, aesthetically and, in the end, cosmologically. It is impossible now to discern what the relative importance of these different spheres was at the time, and in what measure they *consciously* influenced the design: much as in present-day design it is often hard or impossible to distinguish between these different spheres as motivations, not least because they often are not consciously or explicitly thought about by the designers.

All this does not mean that complicated methods of design were not used at all in the planning of urban ground plans in the Middle Ages. A very important hypothesis concerns the medieval new towns of San Giovanni Valdarno and Terranuova Bracciolini, founded by the Florentine city-republic in the

early fourteenth century. Elaborating on a rather vague theory by Enrico Guidoni, Friedman has demonstrated clearly that it is highly probable that the plans of these towns were designed by use of a geometry that is even more complicated than that Bucher suggested for Grenade.³¹ I have studied the plans of those towns closely, and found that the complex geometrical design suggested by Guidoni and Friedman to have been used at San Giovanni and Terranuova, and which Friedman demonstrated to be very probable, may have also been used in the other Florentine foundations of Castelfranco di Sopra and Scarperia.³²

This complicated method of design by use of complex geometrical manipulations was not, however, a common feature in medieval urban planning. As far as I know, these are the only examples where the use of such a method has been clearly demonstrated. Further, although there are other hypothetical proposals for complex geometrical town-plan designs in the Middle Ages,³³ most of these seem quite improbable to me. It would be useful and worthwhile, nevertheless, to do more research on these, and other possible cases.

The allotment of the fields surrounding Grenade-sur-Garonne

Another interesting aspect of the plan of Grenade is to be found in the allotment of the rural area immediately surrounding the town. It has aroused the attention of students of settlement history that the allotment of the fields north and south of the town fits in a grid which is determined by the street alignments that protrude from the town, spaced at 55.05m. In the act of *paréage* for the new town of Grenade, it is stated that the *bastide* foundation is planned to contain, apart from the 3000 house lots, 3000 garden plots (a quarter of an *arpent* in size, costing 3*d.* per year) and 2000 fields of arable (one *arpent* in size, costing 10 *d.*).³⁴

Attention has been focused on the allotment of gardens and fields only relatively recently, especially by Jean-Loup

Abbe and Cedric Lavigne. These authors argue that scholarly attention has been concentrated too much on the urban structure, at the cost of attention to the rural land division, which, according to them, is an integral part of the structure of a settlement.³⁵ According to Lavigne and others, the lines of the streets that extend north and south of the built-up area of the town are the dividing lines between the original rural garden plots and fields (Figure 4). From this they conclude that house-, garden- and arable-plots were allotted in the same overall structure.³⁶



Figure 4. Grenade and its surroundings. The basic structure of the fields that corresponds to the direction and structure of the town plan is indicated.

In my opinion, this is only partly true. The land immediately north and south of the town was, at least in considerable part, intended for house lots that were originally planned, but were never taken up by tenants. If it is correct that the original size of the standard house lots was 9.175m x 27.525m, the number of lots within the old boundaries of the town – marked to the north-west and south-east by boulevards which most probably replaced late-medieval ditches, to the south-west by the River Save and to the

north-east by the step of the Garonne terrace, which still forms the boundary on that side – would be about 750 at most.³⁷ So the town as it was originally intended, with 3000 house lots of 5 x 15 *brasses*, must have been four times as large!

Contemporary documents state that, at the end of the fifteenth century, only about 800 lots had been taken up.³⁸ According to Lavigne, the foundation of Grenade was planned to cover at least 1635ha: 71ha for the town itself, 427ha for gardens and the rest for the fields.³⁹ The lines which today extend outwards from the town into the surrounding area continue for over 1km to the north-west and over 2km to the south-east. It is clear that this allotment covers an area which is far greater than the 71ha built-up area of the town as it was planned; but the area is considerably smaller than the 3000 house lots and garden lots together (498ha).⁴⁰ Since the garden lots were usually situated closer to the built-up area of the town than the agricultural fields, and since their size was planned to be only six times that of a house lot (while the fields would be 24 times as large if we follow Lavigne), it seems logical that it would be the garden lots rather than the fields that were planned within the lines of the same overall layout. So, in the case of Grenade, house lots, and at least some of the garden lots, must have been planned and laid out within the same overall grid structure. The fields, however, were not allotted in a corresponding structure.⁴¹

Conclusion

The layout of the town of Grenade-sur-Garonne was probably not designed by way of complex geometrical manipulations, but neither did it simply follow the lines given by the allotment of the fields in the surroundings of the town. Instead, the number of desired households for the new town was determined, and a standard lot size was chosen with dimensions in rounded numbers of a traditional local measure of length, in such a way that the dimensions of length and width would have a simple

relationship and the lot would have a useful size for a normal urban household. Subsequently, these lots were arranged in three different sizes of chequers, so that the smallest ones would be square, the larger ones would have the dimensional relation 2:3 and the largest ones 1:2. One of the square blocks in the centre of the layout was left open to give room for the market place, which preferably seems to have been square or nearly square in the *bastides* of south-west France. The streets were given widths as required by their intended functions, presumably laid down in specified dimensions of two different widths. A square of twelve house lots was reserved for the town church. Outside the area that was planned as the built-up core of the settlement, the lines of the streets were extended to the space which was planned for the garden lots belonging to the new settlers, so that they could easily be reached. This was possible without having to overcome barriers in the landscape because to the north-west and south-east of the town there were no natural bounds, and defences were not planned.⁴² The areas of garden plots and fields of arable were also determined in the process of planning. It is most probable that the basic grid structure, wherein some of the gardens would be quartered, was initially laid out according to the lines of the north-west to south-east streets of the town. The rest of the gardens and the fields of arable were not included in this overall structure.

The basic problem with which this paper began was the question as to whether it is true that the town plan of Grenade was designed by the use of complex geometry, as has been claimed by several scholars. After comparing this geometrical hypothesis with measurements in the modern town plan, it appears that this is unlikely. Instead, there is a much simpler interpretation, that explains the measured dimensions much better. Apparently, though, this simple and obvious 'metrological' explanation has been less attractive to other writers on the design of Grenade's plan. It seems that many wanted to believe in complicated geometry as the

basic principle of design, rather than simply to look at the historical material, and measure the dimensions in the actual plan, or take in the information of the act of *paréage*, which states that the house lots were to have a standard size. From this standard size it would seem more logical that fixed numbers of these lots would make up the chequers, rather than geometrical manipulation. Apparently the idea of a complex geometry lying behind medieval architectural design is so dear to many people, or is found so natural, that they take Bucher's hypothesis, with its many mistakes and unsubstantiated statements, as the obvious truth. This is far from unique: many theories have been put forward over the last 150 years or so that suggest complex geometrical figures underlying medieval architectural design, based on very poor and often far-fetched sources, and verified inadequately.

The basic point here, it would seem, is that the idea of geometry underlying medieval design, often referred to as 'secret' or 'sacred', is not just fed by historical sources, which are often hard to interpret, but probably more so by the idea of the medieval mind as thinking symbolically and mystically. Of course, this idea is correct up to a certain point, but this does not mean that medieval man could not think rationally, and could not lay out a town on the basis of 'simple' metrology, with or without explicit, or 'secret', symbolism in the underlying form or numbers. In many ways, medieval man thought much as we do: only too often we do not think or act as rationally as we claim, or as rationally as we believe. From the Middle Ages up to the present, architects and town planners have used geometrical forms and manipulations to inspire the forms they designed out of cosmological philosophies, for reasons of symbolism or just as a rule of thumb for designing pleasant proportions or sound constructions. But, equally, arithmetical numbers and proportions could be used based on the same motives. In my opinion, there is no reason to believe that this was fundamentally different in the Middle Ages than it is now.⁴³

Notes

1. Binding, 1985, 1993, pp. 340-53; Bucher, 1979; Naredi-Rainer, 1982; Shelby, 1983, pp. 209-12. The interpretation of many of these sources is still a matter of debate (Hecht, 1969-71; Surdèl, 1993). The only sources that are very clear about the use of geometry for proportioning elements of gothic churches and designing decorations are from the fifteenth and sixteenth centuries, written in Germany (Hecht, 1969-71, 22, pp. 214-15). One of these sources, for instance, is the fifteenth-century tractate *Geometria Deutsch* by Mathias Roriczer, master mason of Regensburg (Shelby, 1977).
2. In general: Binding, 1985, 1993; Bucher, 1972, 1979; Harvey, 1972; Naredi-Rainer, 1982; Shelby, 1986; Simson, 1956; Wittkower, 1949. Strong opponents of what, in their opinion, is an overrated value of design geometry are Hecht (1969-71) and Surdèl (1993).
3. Hecht, 1969, pp. 272-309.
4. See also Naredi-Rainer, 1982, p. 216, n. 239.
5. Nonsense theories concerning medieval architectural design by way of geometry can be found, for instance, in Boer, 1948; Burgers, 1996; Charpentier, 1966; Freckmann, 1965; Kottmann, 1971; Lesser, 1957; Mössel, 1926; Schneider Berrenberg, 1988. See also Hecht, 1969-71; Kruft, 1985, p. 40; Naredi-Rainer, 1982, p. 216, n. 239.
6. This view is largely derived from writings of nineteenth-century scholars such as Ratzel (see Carter, 1975), Ruskin (1849), Viollet-le-Duc (1854) or Sitte (1889, and especially the internationally influential French edition of Sitte by Camille Martin: Sitte, 1902). The idea remained very much alive, even dominant, in many later writings, amongst which Le Corbusier (1971) has been important. The idea still lives on in recent works, including Parker Pearson and Richards (1994, p. 59) and influential general encyclopedias such as *The dictionary of art* (Turner, 1996, 31, p. 712) or the digital *Microsoft Encarta 98 Encyclopedia* (1993-97, 'City Planning').
7. See, for more or less general descriptions, Beresford 1967; Guidoni, 1992; Mumford, 1961.
8. As is clearly demonstrated in Beresford,

- 1967; Guidoni, 1992; Lavedan and Huguency, 1974.
9. For instance, Buselli, 1970, on Pietrasanta and Camaiore, in Tuscany; Dewald, 1959, on Utrecht in The Netherlands; Fernie and Gauthiez (both in Gransden, 1998) with respect to Bury St Edmunds and a number of medieval towns in Normandy; Guidoni, 1992, extending Zagrodzki's theories to *bastide* towns in south-west France; Higounet, 1984, on the *bastide* of Vianne; Morelli, 1994, on Pontedera, in Tuscany; Schütte (see Nitz, 1996, pp. 65, 88) on Göttingen in Germany; Spagnesi and Properzi, 1972, on Cittaducale in Abruzzo; and Zagrodzki (n.d.), especially considering Polish towns, but claiming general relevance. An especially interesting case is to be found in the Florentine new towns built in the first half of the fourteenth century, because on these six towns no less than seven different authors have launched different theories on the design of their ground plans by way of complex geometry (Baldari, 1980; Buselli, 1970; Carli, 1981; Friedman, 1988; Guidoni, 1970; Heuvel, 1983; Higounet, 1962).
 10. Binding, 1993; Naredi-Rainer, 1982; Wittkower, 1949.
 11. This document is in the archives of the Haute-Garonne district, no. 108 H 15 (*expédition*), and is published in French in Rivals, 1986, pp.78-88.
 12. See Beresford, 1967; Lavedan and Huguency, 1974; Lauret *et al.*, 1988; Randolph, 1994; Rivals, 1986.
 13. Many a *bastide* was planned for no more than, say, a hundred families.
 14. Bucher, 1972, p. 43.
 15. Bucher does not really explain what he exactly intends, but he probably means the rectangle with the dimensional relation 1:0.618 (which is the 'golden section').
 16. The Zähringer new towns were founded between the early twelfth and thirteenth centuries. Most famous among them are Bern and Freiburg-im-Breisgau (Divorne, 1993; Schwineköper, 1980). Since Bucher is unclear about what he exactly means, there is no point in trying to verify his ideas concerning Sainte-Foy-la-Grande and the Zähringer new towns. One can immediately see, though, that such a method of design would be less likely in these cases. While in Sainte-Foy the general type of plan with different block lengths is more or less analogous to that of Grenade, the dimensions vary much more from block to block, so it would be hard to determine what might be the originally intended standard size, if there was such a standard (plan in Lavedan and Huguency, 1974, Fig. 268). The Zähringer new towns, which vary considerably in plan form, are much less regular in their layout, the plans diverging more from orthogonality and the dimensions being much less equal within the individual plans (plans in Lavedan and Huguency, 1974, Figs 459, 460, 465, 466 and 468).
 17. For important criticism of similar theories, see Hecht, 1969-71. The dimensional relation of $1:\sqrt{2}$, or rather the figure of the square within a comprising square which is rotated over 45° , in German called *Vierung über Ort*, is regarded by many authors as very important and 'commonplace' in medieval art and architecture. I am not suggesting that this ratio was not used in the Middle Ages, but that many hypotheses claiming its use in architectural design distort actual dimensions or postulate more complex rather than simpler design methods (Hecht, 1969-71, 22, pp. 214-15; Helten, 1992, pp. 12-13). The same is even truer of the even more speculative use of the ratio of the 'golden section', which is not clearly documented until Luca Pacioli's *De divina proportione* of 1479.
 18. Friedman, 1988, pp. 132, 259, n. 39. It does not make much difference that, in my opinion, Friedman did not understand correctly what Bucher exactly meant (instead of the *auron* he takes the diagonal of the 'larger block' as the side of the 'largest block'), because either way the theories do not correspond with the real measurements (116.6m - 119.4m measured by Friedman; 110.8m calculated by Friedman; 103.55m with the *auron* based on the square with 64m sides). I found that Friedman's measurements do correspond fairly well to the ones I measured in the cadastral plan of Grenade (see below), which are in general about a half per cent larger.
 19. Kostof, 1991, p. 128.
 20. Randolph, 1994, p. 300. In referring to the blocks 'to the east and west' of the square Randolph must mean the 'larger blocks'

- (actually NNW and SSE, to be exact), which is apparent from the non-oriented illustration he took from Friedman.
21. See note 16.
 22. Lilley, 1998, 1999; Slater, 1999; Scrase, 1999.
 23. This cadastral plan is in the office of the regional cadastre in Toulouse Colomiers, entitled *Grenade-sur-Garonne, section C, feuille 3. 1826, rev. 1938. Édition à jour 1989*.
 24. The first dimension is calculated from 12 measurements for the north to south length of the square blocks, 55.08m, and 37 measurements of the east to west width of all the blocks, averaging 55.02m, ranging from dimensions of 53.87m to 56.37m; the second dimension is calculated from 22 measurements, ranging from 80.12m to 84.37m; and the third from 21 measurements, ranging from 108.25m to 112.25m. By comparison Friedman found dimensions of 55.4m, with variations of only 20cm, 82.4m and 109.2m (probably on the south-east side) / 112m (probably on the north-west side) (Friedman, 1988, p. 259, n. 39); Lavigne mentions measurements of 56m, 85m and 110m (Lavigne, 1996, p. 192). In both cases it is unclear what exactly they have measured, so I cannot say how the differences arise.
 25. Taking 55.05m as the basis, the 'larger block' would theoretically measure $1.5 \times 55.05\text{m} = 82.57\text{m}$, and the 'largest block' $2 \times 55.05\text{m} = 110.10\text{m}$. Thus the differences from the averages are negligibly small. According to Bucher's theory, starting with the same basis, the 'larger block' would be $\sqrt{2} \times 55.05\text{m} = 77.85\text{m}$ long, and the 'largest block' would be $1.618 \times 55.05\text{m} = 89.07\text{m}$. According to Friedman's (and Kostof's) understanding of Bucher's theory, the 'largest block' would measure $\sqrt{3} \times 55.05\text{m} = 95.35\text{m}$. Thus it is clear that the 'simple' multiplication of the central square blocks by 1.5 and 2 respectively is the option that best fits the actual dimensions in the town plan.
 26. *Brasse* means arm, but especially in Southern France the *brasse* or *brassée* had the length of a man with both arms outstretched, fingertip to fingertip. This was brought into the anthropomorphic dimensioning-system as 5 or 6 feet, or somewhere in between. From the eighteenth century onwards the standard would be 5 feet / 1.624m (Zupko, 1978, p. 30).
 27. Lavigne, 1996, p. 192, who unfortunately does not mention on what source this is based.
 28. Frölich, 1953, p. 80; Meckseper, 1982, pp. 70-1; Nitz, 1996, pp. 73, 81, 1998, pp. 74-5, 1999, pp. 95, 102-109; Schweincköper, 1980, p. 151.
 29. The breadth of the widest streets is the average of 45 measurements, ranging from 7.5m to 9.25m; the breadth of the two narrower streets is calculated from 13 measurements ranging from 6.60m to 7.75m.
 30. To be accurate, however, it would be better to measure the width of the streets in reality. From the measurements of Friedman (1988, pp. 132, 259, n. 39), it may be deduced that he takes the widest streets as being 9.6m wide.
 31. Friedman, 1988; Guidoni, 1970.
 32. Boerefijn, forthcoming.
 33. See note 9.
 34. Abbe, 1997, p. 311; Lavigne, 1996, p. 192.
 35. This does not only apply to Grenade, according to Abbe and Lavigne, but to many more medieval planted settlements. They studied a number of cases, but only in France, especially *bastides* (Abbe, 1993, 1996, 1997; Lavigne, 1996).
 36. Abbe, 1997, pp. 310, 317; Lavigne, 1996, p. 193. Based on this interpretation of the structure of Grenade and its surroundings, some scholars have taken on the idea that geometrical structural unity in town and fields was normal for *bastides* that were founded by Cistercian abbeys (Guidoni, 1992, p. 108; Heers, 1990, p. 107; Higounet, 1975, p. 272).
 37. The old core of Grenade measures about 525m x 500m (26.25ha).
 38. A number of these lots were probably already smaller than the originally intended standard lot. According to Higounet, the disappointing number of settlers was the reason for a documented operation of re-allotment in 1332-33, in which the form of the built-up area was re-planned: limited to the more or less square block we find since at least the early nineteenth century, instead of the rectangular form which must have been planned originally (Higounet, 1992, p. 147). According to Saint-Blanquat, this

repericare, as it was called, may have been necessary because the distribution of the lots had not been orderly, so that houses were built in the wrong places and fields were cultivated with the wrong crops (Saint-Blanquat, 1985, p. 65).

39. According to Lavigne, this means that the house lots were to measure 0.0237ha (which, strangely enough, does not correspond to the dimensions of 8m x 24m he suggests, which would result in a surface of 0.0192ha), the garden lots 0.1422ha (which is six times as much) and the fields 0.5690ha (four times as much) (Lavigne, 1996, p. 192). According to Zupko (1978, p. 8), however, the *arpent* was mostly of 100 square *perches*, and the *perche* could vary from 18 to 22 feet. But in the south of France there were even more and greater variations: an *arpent* could also be 144 square *perches* or 144 square *escats*. In hectares, variation could be as great as 0.1367ha - 0.3812ha. Lavigne again does not mention where he found the numbers he uses.
40. Taking the aerial photograph in Guidoni 1992 (p. 117) as a source, the surface of the area allotted that corresponds to lines that also play a role in the street system of the town is 200ha at most. And we have to consider here that the size of the house lots according to Lavigne is smaller than in my reconstruction. Taking the house lot from my reconstruction (9.175m x 27.525m; 0.0252ha) as a basis, the area needed for the house lots only would be 75.76ha. So, adding space for church, streets and town square, the required ground area would measure close to 100ha.
41. Comparable situations can be found, for instance, in Bunschoten in the Netherlands and in New Winchelsea in England. In both cases it may, at first sight, seem as if the town also fits to the allotment of the rural fields surrounding the town. But in Bunschoten it appears that this is just the structure of the planned town that was laid out: less than one-third of the intended size was actually filled. In New Winchelsea, on the other hand, the town seems to have reached its intended area, but has shrunk considerably since the fourteenth century (Beresford, 1967, pp. 14-28).
42. The idea that a *bastide* was always a strongly fortified town is an old misconception based on a confusion over terms. In old French the word *bastida*, which we find in contemporary documents relating to the newly-founded towns in south-west France in the thirteenth and fourteenth centuries, does indeed signify something like 'strengthening' or 'fortifying' (cf. the Parisian *Bastille*) but, just as often, it means 'building' in general (cf. *bâtir*, from the Latin *bastire*). It seems that, especially in the Anglo-Saxon world, the term *bastide* is still mainly used for fortified small towns in the Middle Ages, which is basically wrong (Lauret *et al.*, 1988, pp. 14-15; Randolph, 1994, p. 291).
43. It was in, *inter alia*, the highly influential book *Architectural principles in the age of humanism* by Wittkower, 1949, that the difference between medieval geometry and Renaissance arithmetic was put forward as the basis of architectural design. In this, Wittkower followed many older writings; it is now clear that this contrast is highly exaggerated (see Hecht, 1969-71, 21, pp. 259-62; 23, pp. 66-74).

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